

Integrated Product Design Simulation

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DOME (distributed
object-based modeling
environment)



Publications: <http://cadlab.mit.edu>

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Abstract		
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Classification of Abstract unclassified	Limitation of Abstract UU	
Number of Pages 31		

design context

need

concept

scenario

barriers

application

Integrated Product Design Simulation

Outline

Design context

Need

Concept

Scenario

Barriers addressed

Applications

design context

need

concept

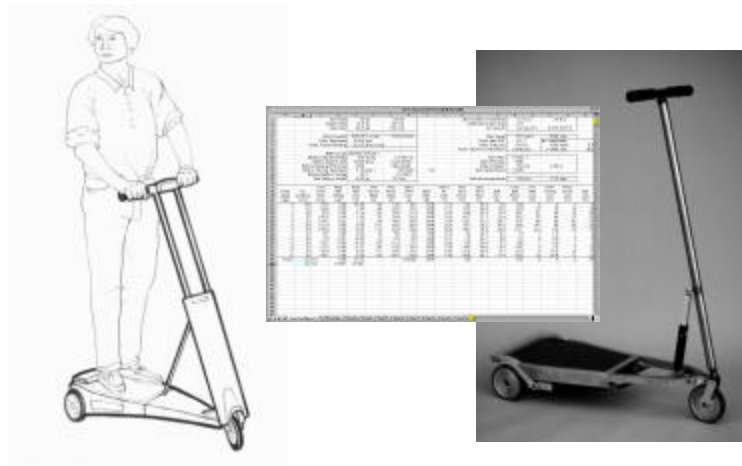
scenario

barriers

application

Product Design

Modeling context

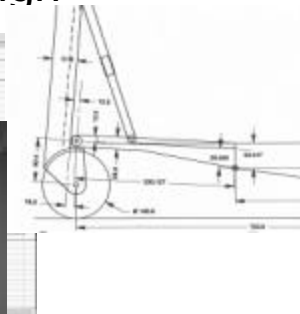


Planning

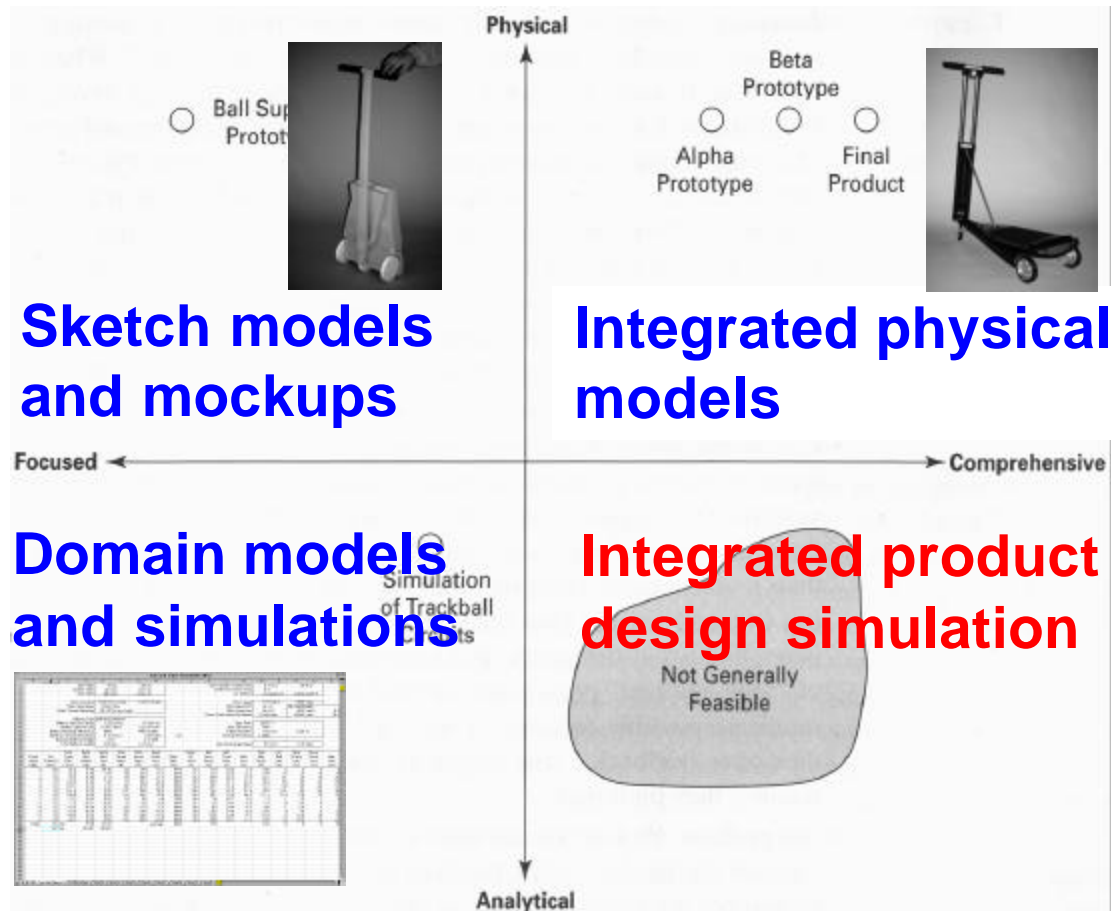
Concept design

Detail design

Testing Ramp up



Design Modeling Techniques



From: Ulrich and Eppinger, Product design and development, 2000

Need

Integrated system modeling and simulation

Mathematically predict and analyze the integrated behavior of products throughout the pre-prototype design cycle

Benefits

Simulation-based integrated system analysis

Polaroid LCD projector

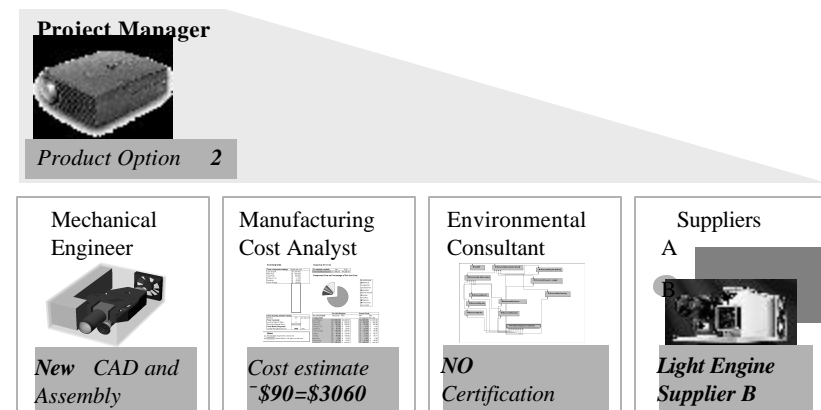
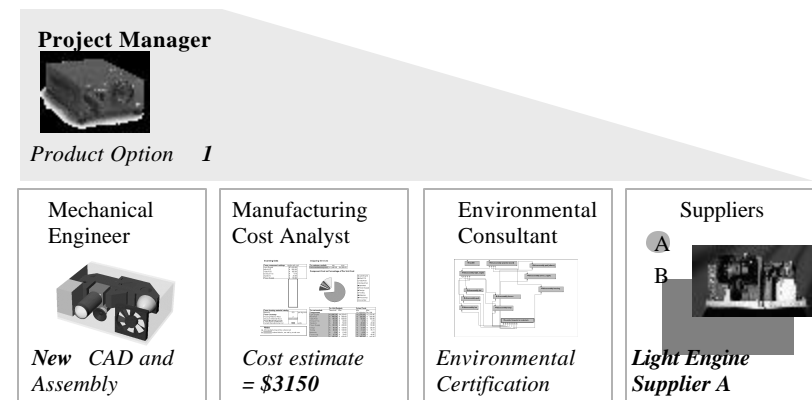
Seamless mathematical
integration:

geometry, engineering,
life-cycle analysis,
customer and
intent-to-purchase simulations

Result:

integrated trade-off
cycle time reduced
from 3 months to
15 seconds

“not generally feasible”



Hypothesis

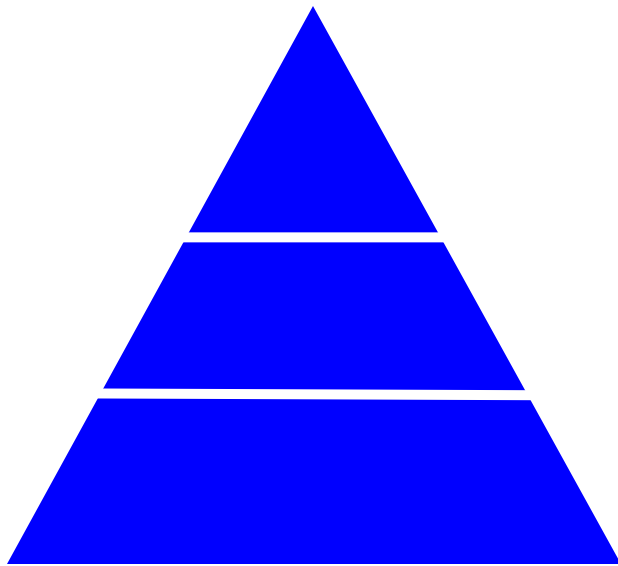
Limitation is simulation synthesis, not analysis

Mathematical system modeling techniques do not match
design synthesis needs

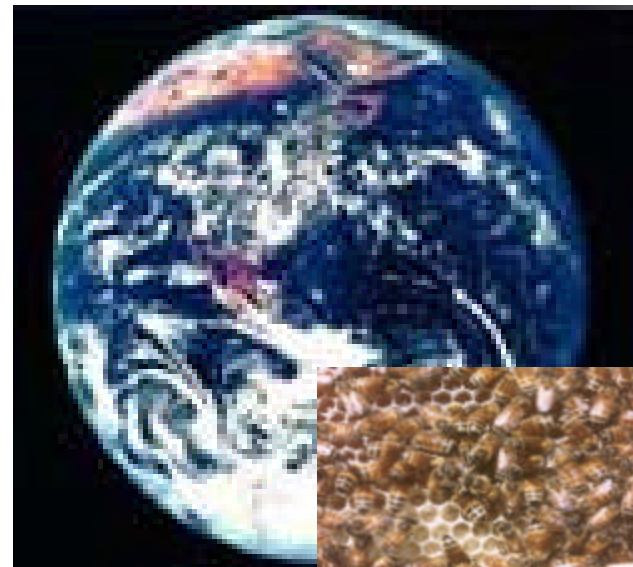
Mismatch

Traditional model integration methods

Explicit, fixed scope,
command and control



Implicit, emergent



Existing methods do not accommodate flexible model growth, change, emergence, or rapid transitions between synthesis and analysis

Synthesis Mismatch

Consequences

Infeasible because of design ...

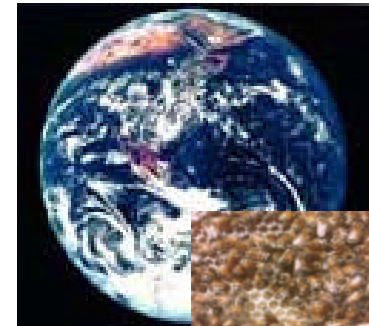


complexity, scale, rate of change

heterogeneity

proprietary knowledge

Cutkosky, 1996



DOME

Research goal

A new infrastructure for building the integrated simulations needed in design analysis

Fundamentally resolve traditional integration barriers

design context

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Future Design

Engineering emergent systems

product



infrastructure



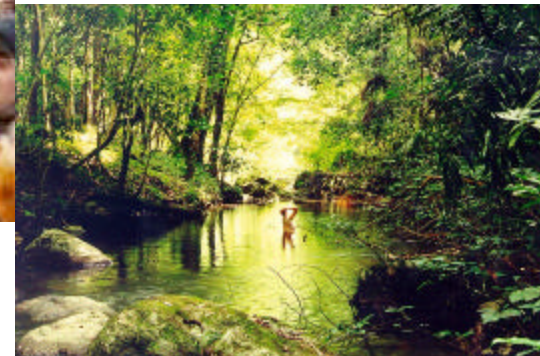
urban environment



society



sustainability



DOME Inspiration

Hypertext (WWW)

Revolution in infrastructure for building information networks—breaking control barriers

Any individual can add content

Any individual can access remote material and create local links to relevant materials

Result: an emergent network of information services

DOME Concept

World-wide Simulation Web

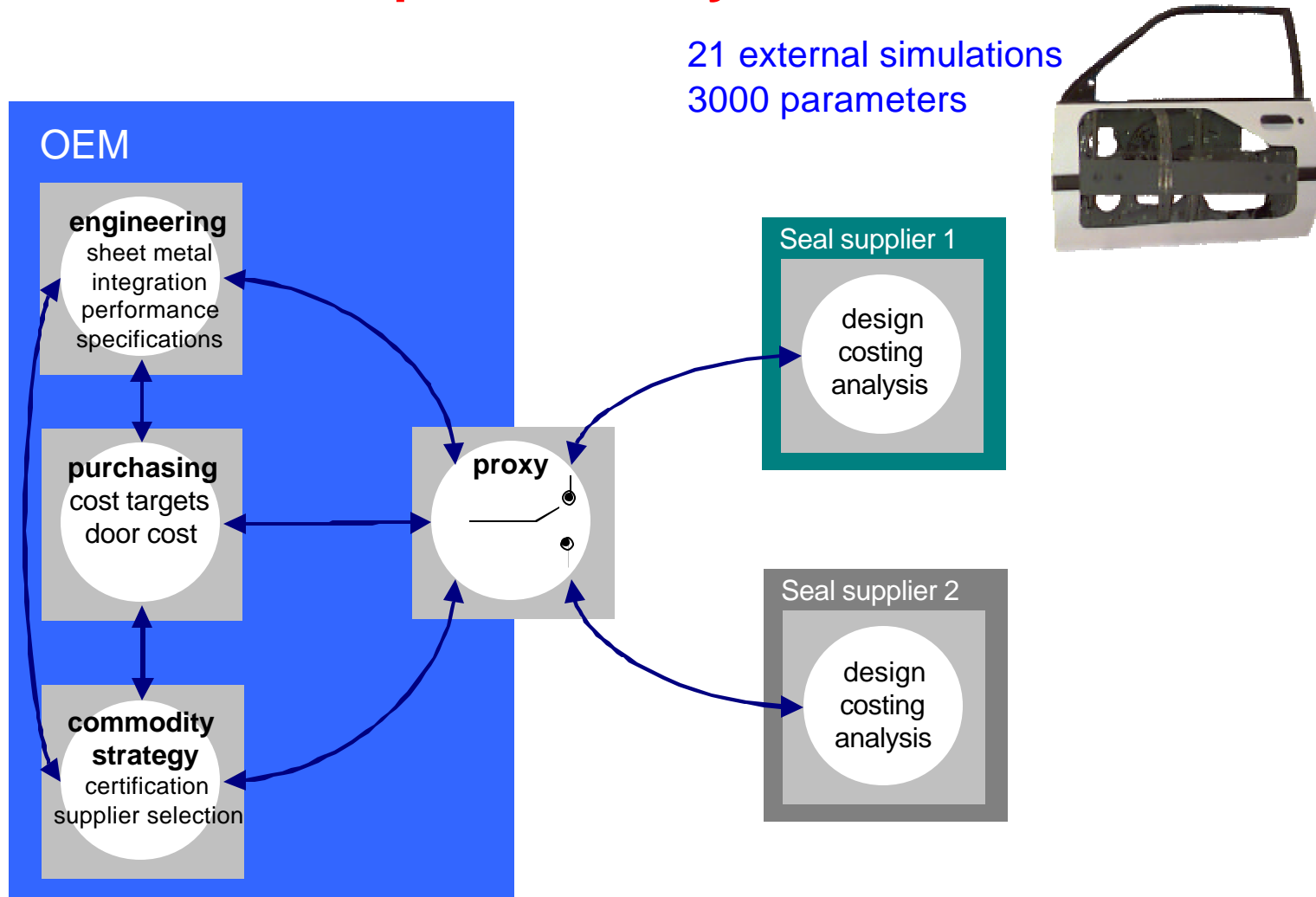
Any individual can make interfaces to focused simulations operable over the Internet

Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

Result: an emergent network of parametrically coordinated simulations

DOME Application

Proof of concept field study



design context

need

concept

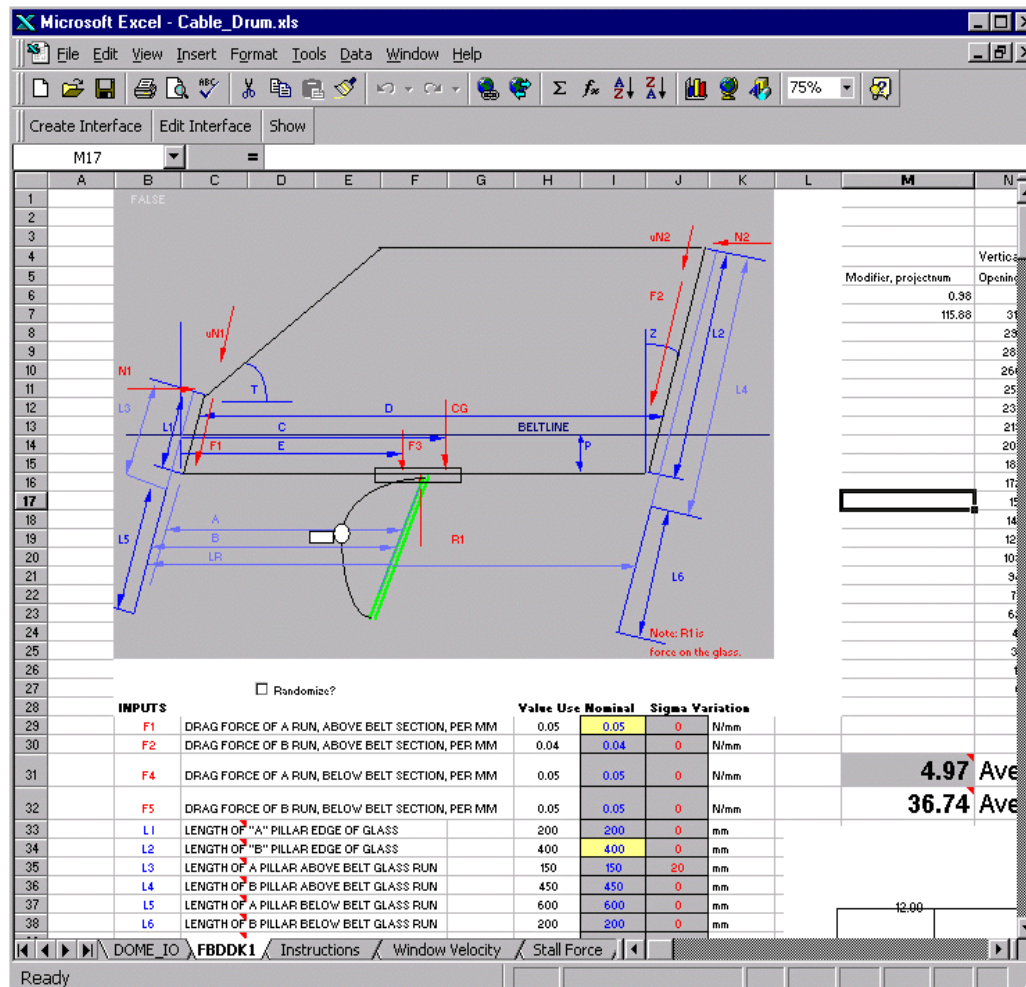
scenario

barriers

application

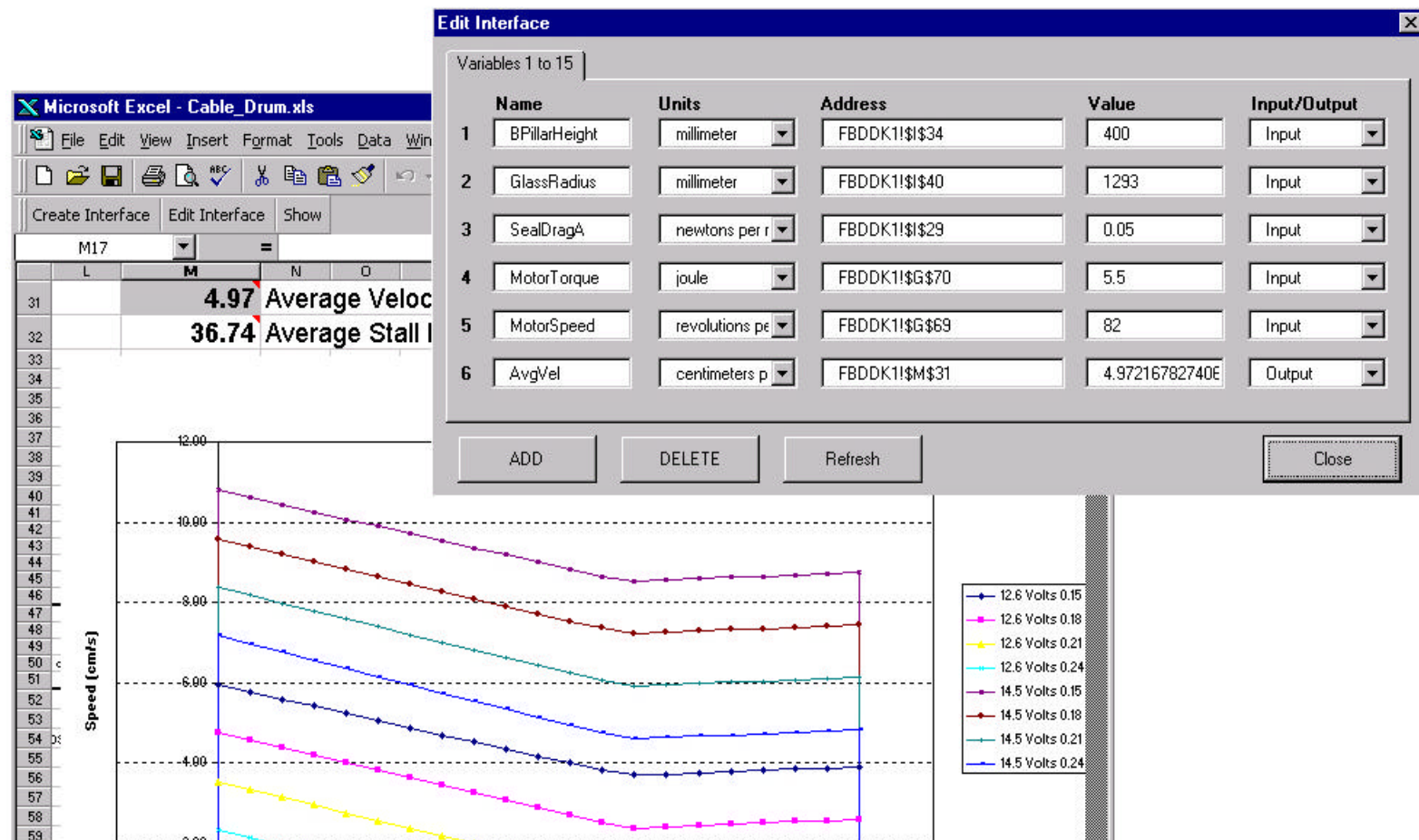
Integrated Simulation Synthesis

Participants build models using tools appropriate for their discipline



Integrated Simulation Synthesis

Participants define parametric interfaces to their focused simulations



Integrated Simulation Synthesis

Participants deploy interfaces on
Internet-accessible DOME servers

The screenshot shows the DOME Client interface in Netscape. The main window displays the MIT CADLAB logo and a login form with fields for Name (wally), Password (*****), and Server (cadlab24). Below the login form is the Alliance for Global Sustainability logo.

A secondary window titled 'cadlab24' shows the address 'ib24/door engineer/simulation_services/velocity_analysis_Excel/' and a tree view of the simulation services. The tree view shows the following structure:

- cadlab24
 - door engineer
 - simulation_services
 - velocity_analysis_Excel

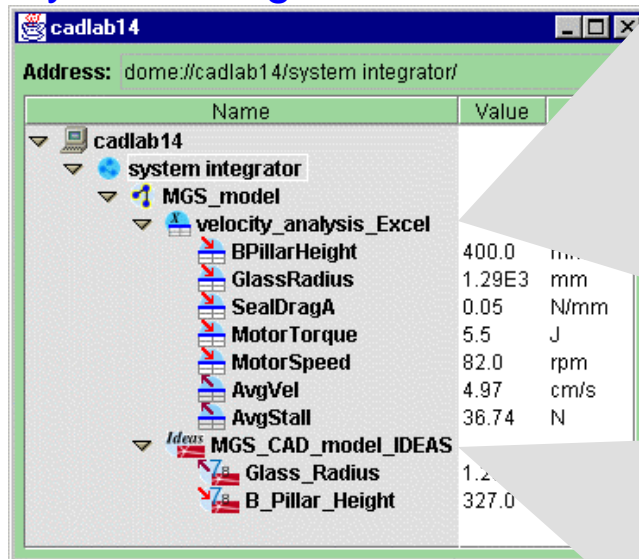
A third window titled 'dome://cadlab24/door engineer/simulation_services/velocit...' shows the details of the 'velocity_analysis_Excel' service. It includes a 'Name' field with the value 'velocity_analysis_Excel' and a 'Type' field with the value 'Excel'. Below this is an 'Excel file name' field with the value 'z:\ntdome\models\cable_drum' and a 'Save Spreadsheet' button.

Name	Value	Units
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvnVel	4.97	cm/s

Integrated Simulation Synthesis

Participants create DOME bridge models between interface elements

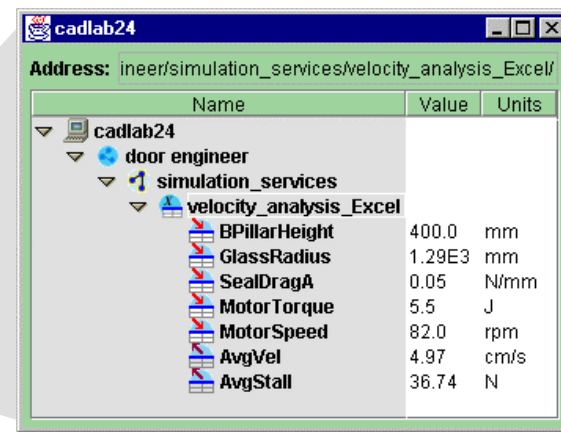
System integrator



Address: dome://cadlab14/system_integrator/

Name	Value	Units
cadlab14		
system_integrator		
MGS_model		
velocity_analysis_Excel		
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvgVel	4.97	cm/s
AvgStall	36.74	N
Ideas MGS_CAD_model_IDEAS		
Glass_Radius	1.2	mm
B_Pillar_Height	327.0	mm

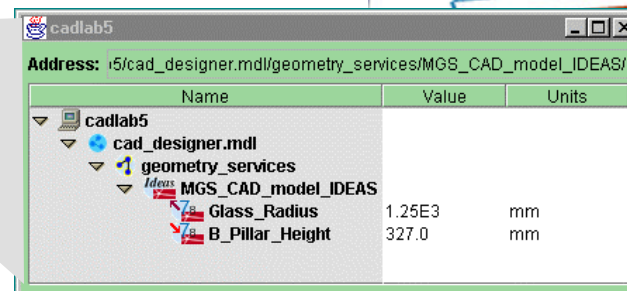
Engineer



Address: ineer/simulation_services/velocity_analysis_Excel/

Name	Value	Units
cadlab24		
door_engineer		
simulation_services		
velocity_analysis_Excel		
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvgVel	4.97	cm/s
AvgStall	36.74	N

CAD designer



Address: i5/cad_designer.mdl/geometry_services/MGS_CAD_model_IDEAS/

Name	Value	Units
cadlab5		
cad_designer.mdl		
geometry_services		
Ideas MGS_CAD_model_IDEAS		
Glass_Radius	1.25E3	mm
B_Pillar_Height	327.0	mm

New Integration Infrastructure

World-wide Simulation Web

Any individual can make interfaces to focused simulations operable over the Internet

Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

A domain independent simulation infrastructure

Integrated System *Analysis*

Participants apply tools to elucidate tradeoffs, optimize designs, and understand system interactions

Examples:

Decision theory (Kim and Wallace, 1999)

Genetic optimization (Gruininger, Senin and Wallace, 1996)

System structure analysis (Abrahamson and Wallace, 1999)

Model customization (Ferara and Wallace, in progress)

Ford Application

Results

Rapid system model development and evolution

(Integration process was 12 person days)

Interoperability of services between heterogeneous applications without sharing proprietary data models

Design tradeoff speed

(Ford engineer to supplier analyst: 10s vs. ~2 weeks)

Rapid design comparison of local design and supplier changes with global tradeoff viewpoint

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New Integration Infrastructure

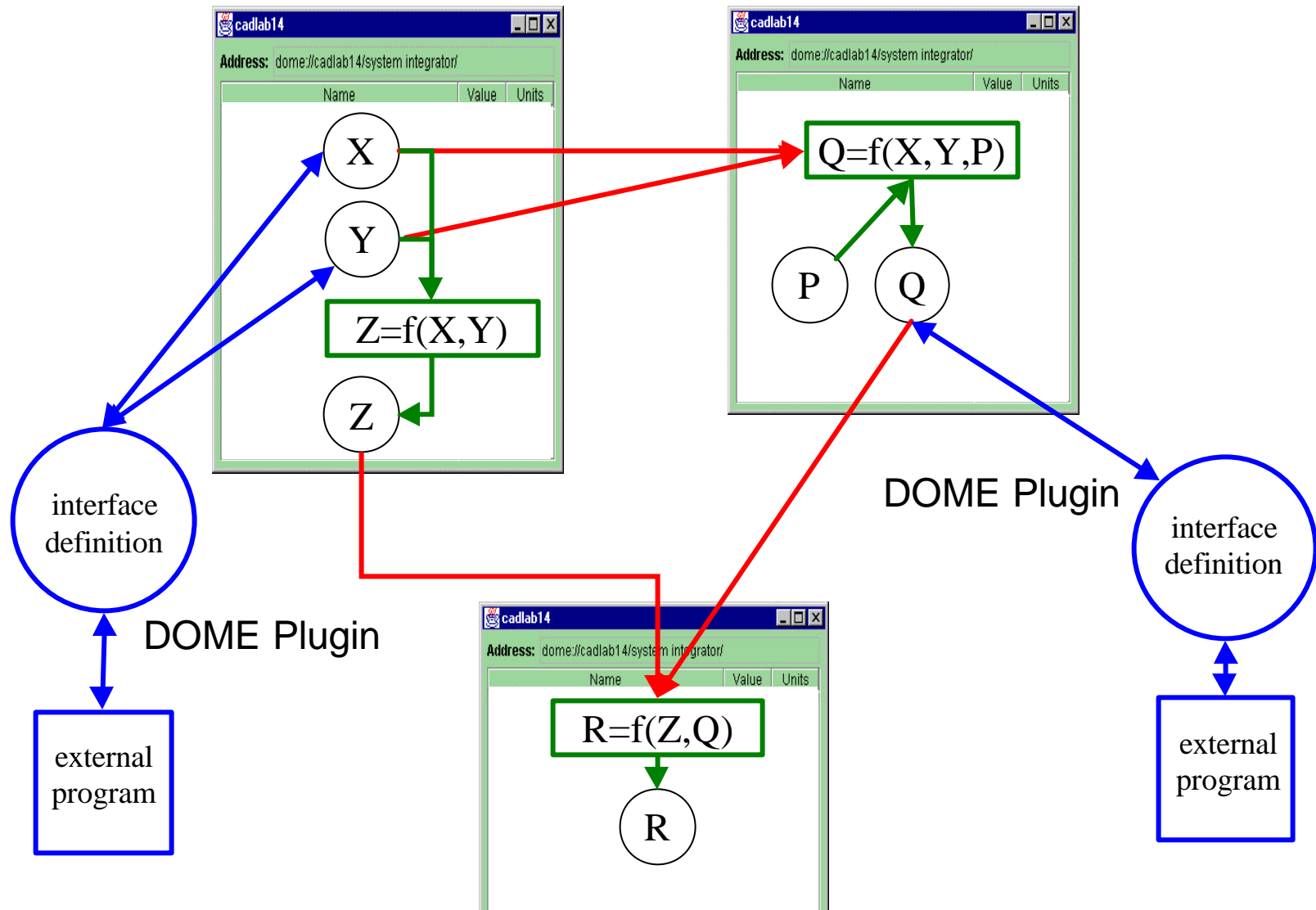
Fundamentally resolve traditional integration barriers

Complexity, scale, rate of change

Emergent vs. explicit system definition

New Integration Infrastructure

Localized definition of interfaces and relationships

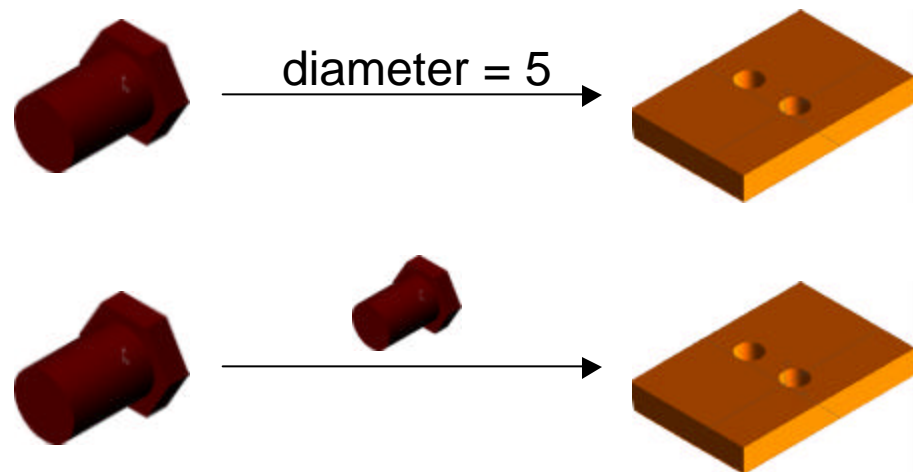


New Integration Infrastructure

Fundamentally resolve traditional integration barriers

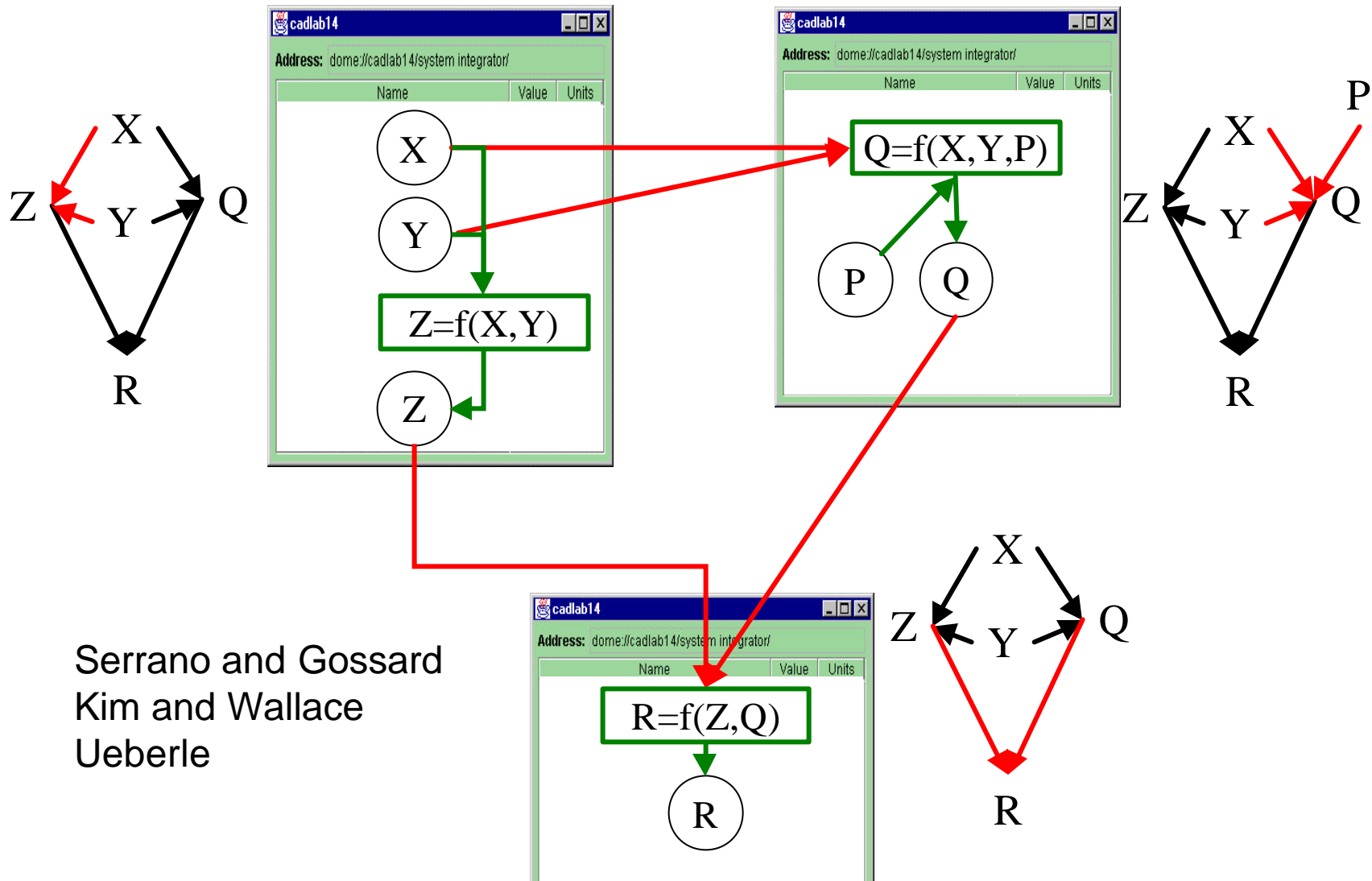
Heterogeneity, proprietary information

Parametric consistency vs. data model sharing



New Integration Infrastructure

Local solvers share causal mapping for externally accessible interface parameters



Industry Pilot Applications

Recently completed or ongoing

Organization

Project

Ford

Door glass system

Integrated simulation across the design/supply chain

Ford

Fuel economy

Integrated technology assessment

Ford

Vehicle platform design

Parametric assemblies with multiple CAD systems

LG Electronics

Air conditioner design

Platform management

Boeing

New materials adoption

Integrated simulation across length scales

US Navy

Aircraft carrier ordnance delivery

Life-cycle cost reduction

Vehicle Platform Application

Geometric assemblies

Traditional integration approach:

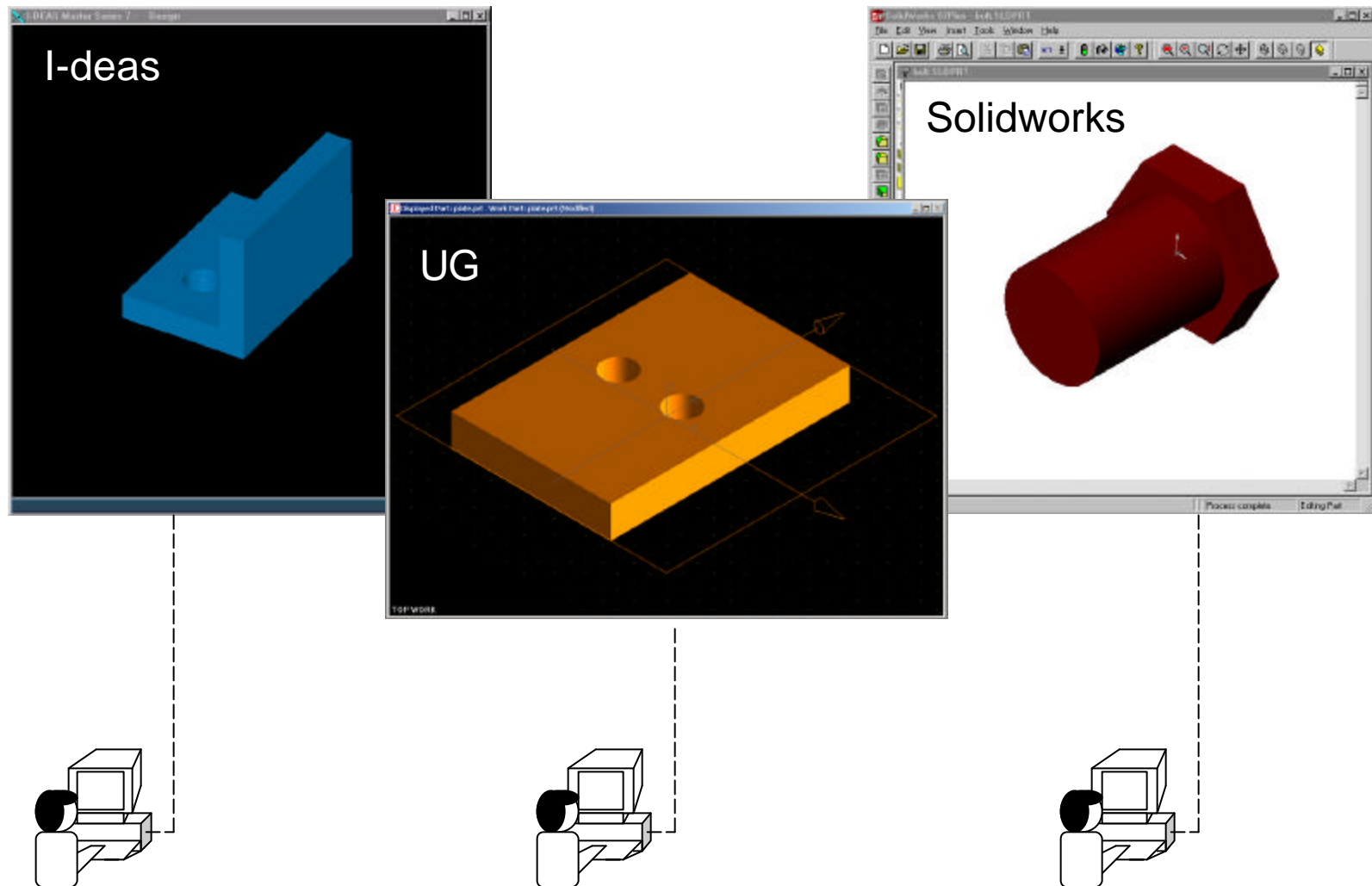
Each company has an official CAD system

All suppliers must use the official CAD system

Suppliers must provide native part geometry to automotive company

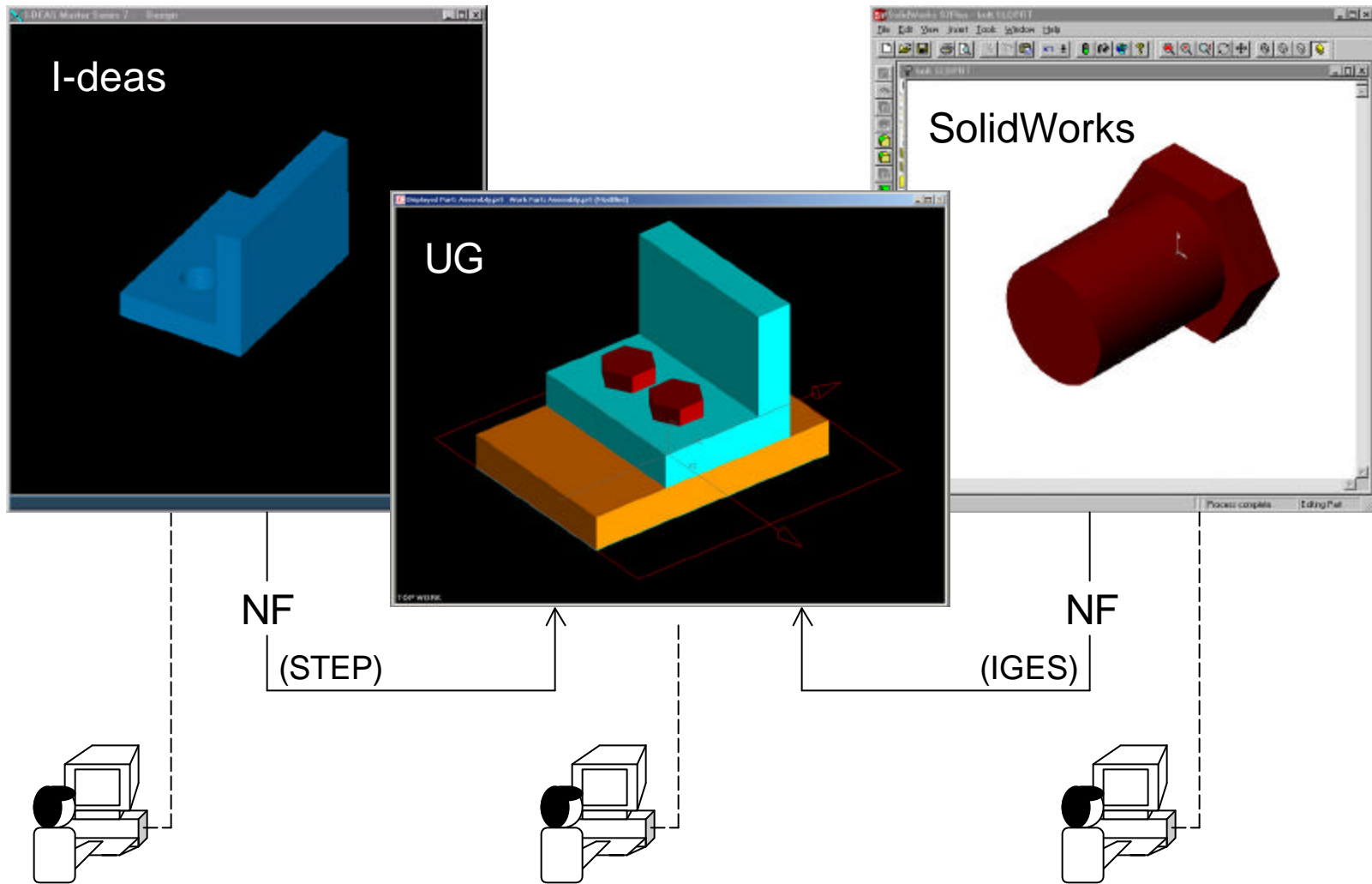
Vehicle Platform Application

Parametrically editable assemblies



Vehicle Platform Application

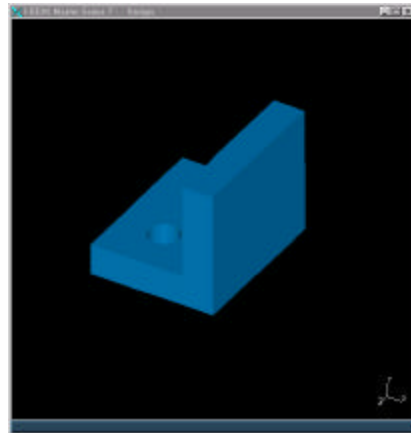
Parametrically editable assemblies



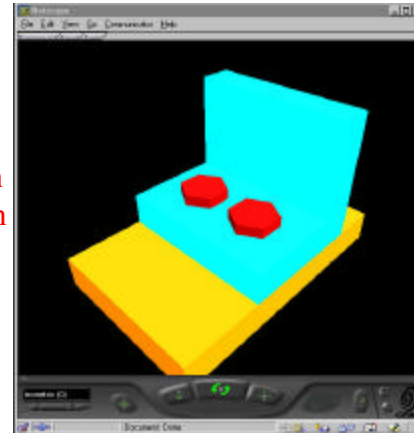
Vehicle Platform Application

Parametrically editable assemblies

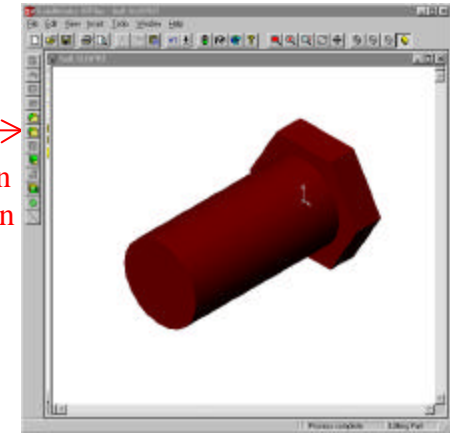
I-deas



UG



SolidWorks



NF

NF

NF

Change in
dimensionChange in
dimensionChange in
dimension

cadlab26

Address: dome\cadlab26\Assembly_Demo

Name	Value	Units
Assembly_Demo		
Bracket_Supplier.mdl		
Bracket		
IDEAS		
Run_Analysis	false	
Analysis_Running	false	
Bracket		
bracket_thickness	0.5	in
bracket_width	3.75	in
bracket_hole_diameter	0.75	in
bracket_hole_spacing	1.5	in
Neutral_File_Export		
Parametric_Inputs		
File_Relationships		
Simple_Demo		

cadlab35

Address: y_Designer.mdl\Bolted_Joint\Parametric_Inputs\plate_length

Name	Value	Units
cadlab35		
Assembly_Demo		
Assembly_Designer.mdl		
Bolted_Joint		
Unigraphics		
Parametric_Inputs		
plate_length	0.75	in
plate_thickness	0.5	in
plate_hole_diameter	0.75	in
Assembly_Relationships		
Bracket_Relationships		
Bolt_Relationships		
Cost		
Excel		
assembly_cost	0.61	\$
Simple_Demo		

cadlab29

Address: dome\cadlab29\Assembly_Demo

Name	Value	Units
cadlab29		
Assembly_Demo		
Bolt_Supplier.mdl		
Bolt		
SolidWorks		
Run_Analysis	true	
Analysis_Running	false	
bolt_diameter	0.75	in
bolt_length	1.0	in
Mass	0.03	kg
Bolt_VBML_Export		
SW_IGES_Export		
Parametric_Inputs		
File_Relationships		
LCA_Demo		
Simple_Demo		

DOME Relations

DOME Relations

Application

Manufacturing object module: MOM

